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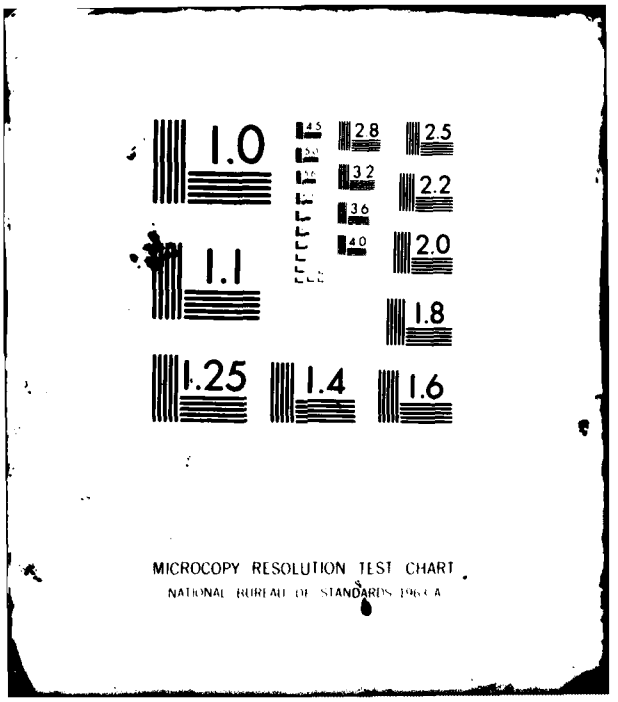
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Since the early 1960's, the DMAHTC/GSS has been conducting gravity surveys in support of the various Department of Defense(DoD) weapon systems. The surveys have been conducted worldwide, on nearshore areas and on land. A variety of supporting positioning systems have been utilized. Gravity Survey Techniques and Data Reduction programs have been developed to process vast quantities of gravity data. The DMAHTC/GSS has been a world leader in establishing gravity base station networks and in writing the first set of gravity survey standards and field survey specifications for land and marine gravity surveys.

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The Defense Mapping Agency Hydrographic/Topographic Center Geodetic Survey Squadron's Gravity Survey Program In Support of DoD Weapons Systems

by

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Geodesist

ABSTRACT

Since the early 1960's, the Defense Mapping Agency (DMA) has been conducting gravity surveys in support of the various Department of Defense (DoD) weapons systems. The surveys have been conducted worldwide, in nearshore areas and on land. To satisfy stringent accuracy requirements, DMA developed data acquisition and reduction specifications and techniques and utilized a variety of positioning systems.

In 1964, two DMA predecessor agencies, Army Map Service and the U.S. Air Force 1st Geodetic Survey Squadron were tasked to provide worldwide gravity data in support of U.S. Air Force (USAF) weapons systems. Midway through the surveys for the USAF, DMA was tasked by the U.S. Navy (USN) to provide gravity survey data in support of Fleet weapons systems.

The task was enormous. Some of the problems facing DMA at that time were:

(1) There were no textbooks on gravity surveys.

(2) There were incomplete gravity survey specifications.

(3) There was no U.S. National Gravity Base Network.

(4) There was no world gravity datum.

(5) There were no uniform gravity standards of accuracy.

(6) There were no computer programs.

(7) There were no trained gravity surveyors.

(8) The gravity surveys would require extensive horizontal and vertical control surveys to satisfy accuracy requirements.

The task required that DMA develop, implement, and execute a relatively new survey technique in a very short time. Essentially DMA had to perform the following:

(1) Analyze requirements; determine areas to be surveyed and required station densities.

(2) Procure gravimeters.

(3) Write survey instructions and specifications.

(4) Calibrate gravimeters.

(5) Train gravity surveyors.

(6) Prepare numerous operations plans.

(7) Conduct the field work.

(8) Reduce and publish the data.

The DMA gravity program can be best reviewed by briefly describing its efforts to establish basic United States and worldwide gravity control networks and then by generally covering its various gravity densification programs.

BASIC CONTROL

This effort consisted of the establishment of the U.S. National Gravity Base Network in coordination with the National Geodetic Survey (NGS) and a worldwide gravity datum in cooperation with the international geodesy and geophysical community. The U.S. National Gravity Base Network consists of 55 gravity base stations in the principal cities of the United States. The network was established with 5 LaCoste and Romberg gravimeters and observed by a series of interconnected closed loops. The Net provides the basic gravity control networks for establishment of densification surveys in the United States.

Toward realizing the improvement of a world gravity datum, DMA was one of the principal agencies working with the International Association of Geodesy

(IAG) to adjust and publish the International Gravity Standardization Net 1971 (ISGN 71). This provided a homogenous world gravity datum with an absolute accuracy of 0.1 milligal. The IGSN 71 is based on the "laserinterferometer falling body absolute device" to determine the acceleration of gravity and vastly improved the accuracy of the world gravity datum. To support this effort and its worldwide requirements, DMA established thousands of gravity stations throughout the world.

GRAVITY DENSIFICATION

This effort consisted of performing numerous anomaly surveys throughout the United States. Approximately 180,000 anomaly stations were observed by DMA field teams. In addition, thousands of stations were acquired from various sources and have been referenced to the National Gravity Base Network.

Since gravimeters are relative instruments, and measure gravity intervals in terms of dial units, they must be calibrated to obtain a gravimeter scale factor which will provide readings in milligals. Therefore, calibration lines were established using the most accurate method for obtaining gravity values. In the mid 1960's the most accurate method of determining the absolute value of gravity was by using pendulum measurements. These pendulum measurements were accurate to 0.5 milligals. This accuracy degraded the potential accuracy of the commonly used LaCoste and Romberg Model G gravimeter, and identified the need for more accurate absolute measurements of gravity which were satisfied by the falling body device mentioned above.

In the late 1960's, DMA was tasked by USN to provide gravity data in near-shore areas (0-30 fathoms) in support of Navy systems. Consequently, the USAF and USN gravity survey requirements were unified into a total gravity survey program.

To accomplish the USN surveys required developing complex marine gravity data reduction computer programs. In addition, LaCoste and Romberg Air-Sea and underwater gravimeters were acquired and utilized by DMA to acquire substantial near shore marine gravity data.

As the terrestrial gravity survey program proceeded, DMA realized that dependence on map derived positions and elevations in support of gravity surveys severely restricted its ability to satisfy accuracy requirements.

In the 1960's, DMA purchased several Sperry-Sun Ground Elevation Meters (GEM) to provide elevations for gravity surveys. A total of 6 GEMs were deployed and made significant contributions to the improvement of the accuracy of terrestrial gravity stations.

However, a fast and relatively inexpensive survey system to provide positions and elevations for the gravity stations was still needed. New systems were creating vast gravity requirements which could not be met by existing positioning resources. To solve this problem, DMA procured a Litton Inertial Surveying System. This system, the Inertial Positioning System 1 (IPS 1), was designed to provide rapid and accurate positions and elevations for the gravity surveys. The IPS 1 has proved to be very compatible with gravity survey methods and has provided positions and elevations of sufficient accuracy to meet gravity requirements.

In 1977, DMA was tasked by the USAF to provide gravity data for geotechnical studies in support of new weapons systems. The geotechnical studies were to determine and assist in selecting the most suitable deployment sites for these systems. The gravity surveys were designed on a girded pattern to provide maximum diagnostic data. In addition, closely spaced profiles were surveyed over salient features. Approximately 16,000 gravity stations were surveyed in the Western United States in support of this program, which was completed in

April 1981. During this time, DMA deployed the ABC positioning system, which consisted of a range-range navigation system for positions and vertical angles for elevations. This survey method, originally developed by the U.S. Geological Survey, was very successful in producing about 9,000 positions and/or elevations for the gravity stations. In addition, the IPS 1 was deployed in 1977 in a heliocopter mode, producing a considerable amount of data.

Presently, DMA is tasked by the USAF to provide significantly more dense gravity in the southern California area to support its test activities at Vandenberg AFB. Data acquisition is now in progress or will commence shortly to establish gravity at approximately 10,000 terrestrial and 2,000 near shore marine stations. Because of increased accuracy requirements, vertical and horizontal positioning techniques are being improved to include the use of Doppler Point Positioning and improved inertial navigation systems.

CONCLUSION

Since the middle 1960s, when DMA's predecessors became involved in gravity data collection and reduction, DMA's gravity program has continued to mature. As requirements increase in terms of accuracy and density, DMA will continue to endeavor to find and implement new techniques to satisfy them.